Right Whale Diving and Foraging Behavior in the Southwestern Gulf of Maine

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LONG-TERM GOALS

Mitigation of a variety of anthropogenic threats to endangered baleen whales depends on information about how the whales use the water column. For example, reducing ship strike risk requires an understanding of how much time whales spend at the surface, and mitigating fishing gear entanglements by ground lines requires an understanding of how often and why whales might dive near the bottom. My long-term goal is to characterize baleen whale foraging behavior by studying diving behavior with respect to vertical/horizontal prey distribution, physical water column features (e.g., mixed layer, stratification, turbulence), and the acoustic environment. This approach will allow me to characterize not only where in the water column the whales feed, but also where the prey are located, why the prey are organized as they are, and how the whales respond to variability in both prey distribution and conspecific acoustic behavior. By using this same approach to study several baleen whale species, comparisons between species will ultimately be possible to address fundamental questions about foraging ecology (e.g., variability in foraging strategy induced by morphological constraints and/or prey species/behavior) as well as about differential rates of interaction with human activities.

OBJECTIVES

The seriously endangered North Atlantic right whale is particularly vulnerable to ship strikes and fishing gear entanglements, and there is an urgent need for information about how right whales use the water column to develop strategies to mitigate these anthropogenic threats. Moreover, the right whale sits atop a relatively simple food chain consisting only of phytoplankton, copepods, and whales that can serve as a convenient model to study trophic interactions in the marine environment because both predator and prey can be monitored with available technologies (e.g., animal-mounted archival tags, video plankton recorder). In 2005-2007, we conducted research on the diving and foraging behavior of North Atlantic right whales in the Great South Channel, but in light of the variability in diving behavior that we observed, the sample size obtained during those years was insufficient to completely characterize the whales' behavior. The objective of this project was to extend our observations of right whale diving and foraging behavior by simultaneously collecting behavioral, oceanographic, and prey observations to fully characterize (1) the behavior of the tagged whales, (2) their response to cues from

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Right Whale Diving And Foraging Behavior In The Southwestern Gulf Of Maine	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,Biology Department, MS #33,266 Woods Hole Road,Woods Hole,MA,02543**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Mitigation of a variety of anthropogenic threats to endangered baleen whales depends on information about how the whales use the water column. For example, reducing ship strike risk requires an understanding of how much time whales spend at the surface, and mitigating fishing gear entanglements by ground lines requires an understanding of how often and why whales might dive near the bottom. My long-term goal is to characterize baleen whale foraging behavior by studying diving behavior with respect to vertical/horizontal prey distribution, physical water column features (e.g., mixed layer, stratification, turbulence), and the acoustic environment. This approach will allow me to characterize not only where in the water column the whales feed, but also where the prey are located, why the prey are organized as they are, and how the whales respond to variability in both prey distribution and conspecific acoustic behavior. By using this same approach to study several baleen whale species, comparisons between species will ultimately be possible to address fundamental questions about foraging ecology (e.g., variability in foraging strategy induced by morphological constraints and/or prey species/behavior) as well as about differential rates of interaction with human activities.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**6**	

the physical environment and the prey field, and (3) the physical and biological processes that influence the vertical distribution of copepods.

APPROACH

All work was conducted from the R/V *Tioga*, the WHOI coastal research vessel (Figure 1a), in the Great South Channel in the southwestern Gulf of Maine between Cape Cod and Georges Bank during the spring of 2009. A 4.7 m (15 ft) rigid hulled inflatable tagging boat was deployed from the R/V *Tioga* after whales were encountered (Figure 1b). Right whales were approached in the tagging boat and suction-cup mounted archival tags were attached to the whales from this boat using a 9 m pole (Figure 1c,d). The tag consists of a time-depth recorder, pitch and roll sensors, a VHF radio transmitter, and a high-frequency acoustic transmitter. After successful deployment, the tagged whale was actively tracked via a high-frequency acoustic transmitter incorporated in the tag using two systems: (1) an acoustic receiver and a hand-held directional hydrophone carried in the tagging boat, and (2) a free-floating array of tracking and acoustic recording buoys that is maintained by a second buoy tender boat (Figure 1e). Using the former system, the tagging boat remains near the tagged whale at all times to collect identification photographs, behavioral information, fecal samples (if available), and to record the whale's surface locations. Upon resurfacing after each long dive, the whale's exact resurfacing position is recorded by the tagging boat using a global positioning system (GPS) receiver. This position is then relayed via radio to the R/V *Tioga* and the ship moves to that position to deploy our vertical profiling instrument package (Figure 1f), which consists of a conductivity-temperature-depth (CTD) instrument, fluorometer, optical plankton counter, and video plankton recorder. Tracking and sampling with the instrument package continues until the tag detaches from the whale, floats to the surface, and is recovered. The tag incorporates a corrosive release mechanism that allows detachment after 1-3 hours.

WORK COMPLETED

Fieldwork was conducted aboard the R/V *Tioga* from May 1-25, 2009. A summary of each day's activities is provided in Table 1.

RESULTS

Despite tagging 11 right whales over the course of the field season, we encountered tremendous difficulty in getting the suction-cup tags to remain attached to the whales. We began the field season with a new tag housing that accommodated a larger, more powerful, VHF radio transmitter, but after 3 deployments of this tag with attachments of less than a few mintues (May 11-12), I switched to a tag housing that we had previously used with great success in 2007. Tag attachments with this older housing on May 13 remained extremely short (2 minutes), suggesting that the tag housing was not the problem. I was using brand new Anver suction cups and had used this brand of suction cup with good success for many years, but the new suction cups felt more flexible than some of the older suction cups I had on hand. I began to suspect that the manufacturing process for the suction cups had recently changed, but was assured by the company that this was not the case. I decided to use older, significantly stiffer suction cups for our next day on the water. After this decision, we spent 4 days on the water (May 19-25), but only were able to tag whales during one of those four days. We tagged 4 whales on May 20 with the following results: one tag was knocked off shortly after deployment during a social interaction with another whale, one tag came off shortly after deployment due to a skin irregularity where the tag was deployed, and two tags came off within 10 minutes of attachment at the

bottom of the tagged whales' dive. These latter two deployments may have ended by the tag coming in contact with the bottom, as the whale was foraging near the sea floor (we observed this often in 2005 when whales were feeding near the bottom).

Table 1. Summary of at-sea activities in May, 2009, including the number of whales tagged and the number of "good" deployments (defined as tag attachments of 1 hour or more).

Date	Boats launched	Whales tagged	Good deployments	Comments
5/3/09	No	0	0	Surveyed all day; found 2 whales late in the day, but too late to launch boats
5/4/09	No	0	0	Found single right whale in the morning, then found entangled humpback whale and stood by for disentanglement effort
5/11/09	Yes	1	0	Found many right whales; animals evasive due to loud tag boat engine; tagged one whale but tag detached after only 2 minutes
5/12/09	Yes	2	0	Found many right whales; tagged 2 animals, but tag detached after only 2 minutes
5/13/09	Yes	4	0	Found whales after long search; tagged 4 animals, but all came off within 2 minutes
5/19/09	Yes	0	0	Small groups of 1-4 animals all day; ended up launching at 15:30, but no tags deployed
5/20/09	Yes	4	0	Tagged 4 whales, but no tags stayed on for more than 10 minutes.
5/23/09	Yes	0	0	Found whales, but conditions quite sloppy; no tags deployed.
5/25/09	No	0	0	Found whales early, but the rapid arrival of a 6 ft swell and fog precluded launching small boats.
Total	6 days	11	0	

In addition to the problems with the suction cups, we also lost an entire day of work (May 4) to the discovery of an entangled humpback whale in the Great South Channel (Figure 2). We are obligated to report such encounters, and I felt it important that we remain with the whale until the Provincetown Center for Coastal Studies Large Whale Disentanglement Team arrived on the scene. Due to our remote location, we waited over 3 hours for their arrival, and then remained with the disentanglement team until they finished their work. They successfully removed all gear from the whale. A joint WHOI/PCCS news release on the disentanglement, which was picked up by several news outlets, can be found here: http://www.whoi.edu/page.do?pid=7545&tid=282&cid=57166&ct=162

The reason for the failure of the suction cups is not completely clear. Although the new suction cups were much more flexible than the older suction cups, the manufacturer claims there was no change in the manufacturing process. Even when we changed to the older suction cups, we did not achieve our target attachment times (over 1 hour), despite the fact that these very same tags with the very same suction cups worked well for us in 2007. It is possible that the whales' skin was somehow different this year, or it was covered with some kind of film that made tag attachment via suction cup difficult. I understand that Dr. Susan Parks' team had similar difficulty attaching DTAG's to right whales in Cape Cod Bay in March-April 2009 (1-2 months prior to our work).

The apparent failure of the suction cups was unexpected and extremely unfortunate. From the prey sampling we were able to accomplish during these limited tag attachments, it is clear that right whales were feeding at the bottom on a highly concentrated layer of copepods (exactly the behavior we were

hoping to document during this field season). For the first time, we were able to collect video plankton recorder observations of *Calanus finmarchicus*, the whales' copepod prey, within a few meters of the sea floor, confirming that whales feed on these near-bottom aggregations.

We have access to the NOAA Ship *Delaware II* in the spring of 2010, and will be participating in a 3-week cruise aboard that ship to replicate our efforts this year. We will attempt suction-cup tagging again with a greatly stiffened suction cup, but if we do not have success with that method, we will quickly switch to a new dermal attachment tag that I have used with success on humpback whales, North Pacific right whales, and bowhead whales. This tagging method involves a small implantable anchor from which a recoverable tag trails via a severable tether, and as such, will attach regardless of the whale's skin condition. The use of both suction-cup and dermal attachment tags on North Atlantic right whales are included in my federal permit. With this effort in 2010, I hope to complete this project and publish the results shortly thereafter.

IMPACT/APPLICATIONS

This work will directly help efforts to mitigate the effects of anthropogenic activities on baleen whales by characterizing where in the water column right whales feed and why the prey are organized as they are. Ultimately, our ability to predict or even forecast right whale distribution will hinge on a fundamental understanding of right whale foraging behavior and how that behavior varies with changes in copepod behavior and distribution.

RELATED PROJECTS

The project entitled "Physical and Biological Controls of Copepod Aggregation and Baleen Whale Distribution" (award number N000140811200, PIs Mark Baumgartner, Rubao Ji, Changsheng Chen) is closely linked to this project, as it is focusing on the physical and biological mechanisms that aggregate copepods in the Great South Channel and how those mechanisms influence baleen whale distribution. By understanding the local-scale distribution of prey and the resultant foraging behavior of right whales, we will be able to better characterize the response of whales to the aggregation processes elucidated in this related project.

Figure 1. Methods used for the proposed study. (a) Work was conducted aboard the 60 ft. R/V Tioga. (b) Launch of the 15 ft. tagging boat from fantail of R/V Tioga (note vertical profiling package on the starboard side, and RATS buoys on port side). (c) Approach of two humpback whales showing 9-m tagging pole. (d) Tagging of a North Atlantic right whale. (e) A tagged whale passes a RATS tracking/recording buoy. (f) Deployment of vertical profiling package from the fantail of R/V Tioga.

Figure 2. Entangled humpback whale encountered on May 4 showing an embedded wrap of rope over the back and one of two trailing buoys.